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Online: WPI, JAPIO & EPODOC

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(54) Abstract Title
Solenoid actuated gear engagement mechanism

(57) A gear engagement mechanism includes a selector member (110, fig 2) moved axially by a select actuator solenoid 114 to engage with shift rails (111, 112, 113 fig 2). The solenoid 114 has an armature 116 with a pair of iron cores 124, 126 mounted thereon in an axially spaced relationship. A pair of coils 130, 132 overlap the cores 124, 126 but are arranged to have a different axial spacing from that of the cores 124, 126. The coils 130, 132 have pole pieces 135 which are axially spaced within limits of movement of the armature 116 between a first position P_1, a second position (P_2, fig 4) and a third position (P_3, fig 5) so that the armature may take up three positions in which to engage the shift rails (111, 112, 113 fig 2). Switches 142, 144 selectively connect each coil 130, 132 to a power source 140 or, alternatively, both coils 130, 132 may apply different forces to the cores 124, 126 thereby allowing the armature to take up unevenly spaced positions.

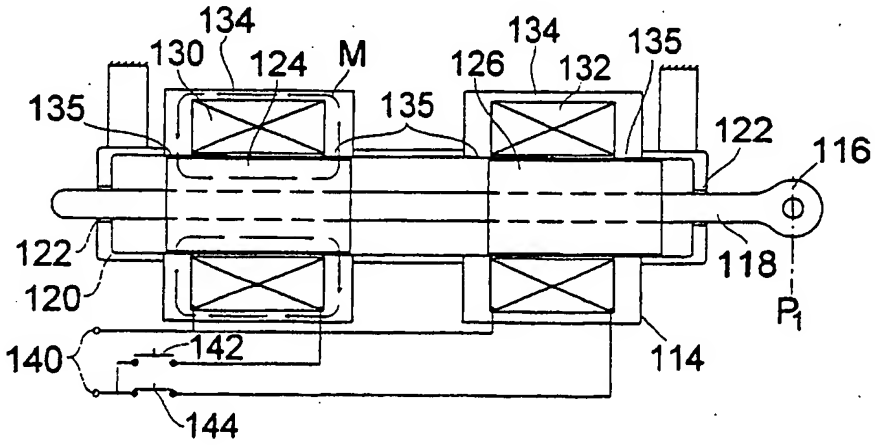

Fig 3.

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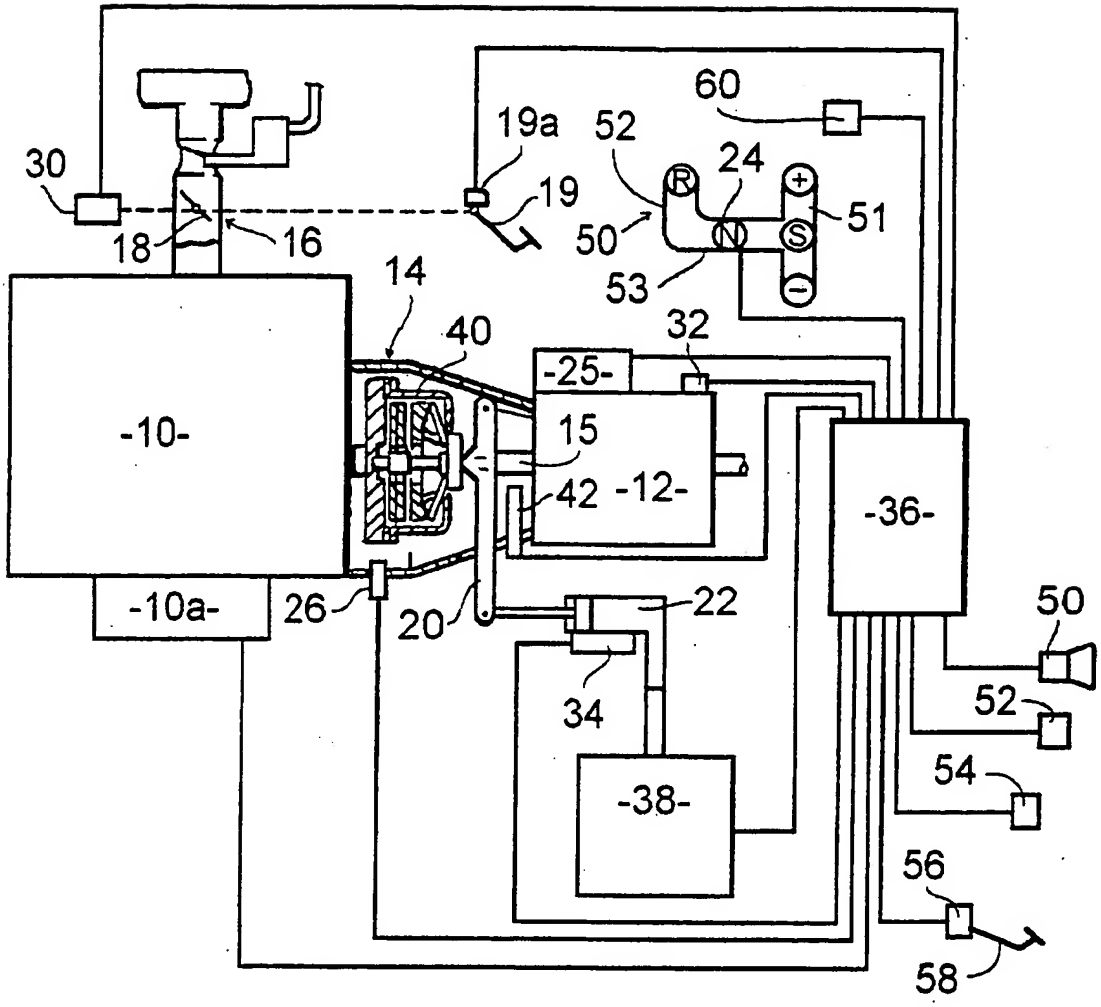

30
18
16
19a
19
60
52
24
R
N
S
+
−
51
50
53
14
40
32
-25-
15
42
-12-
-10-
-10a-
26
20
22
34
-38-
-36-
50
52
54
56
58

Fig 1.

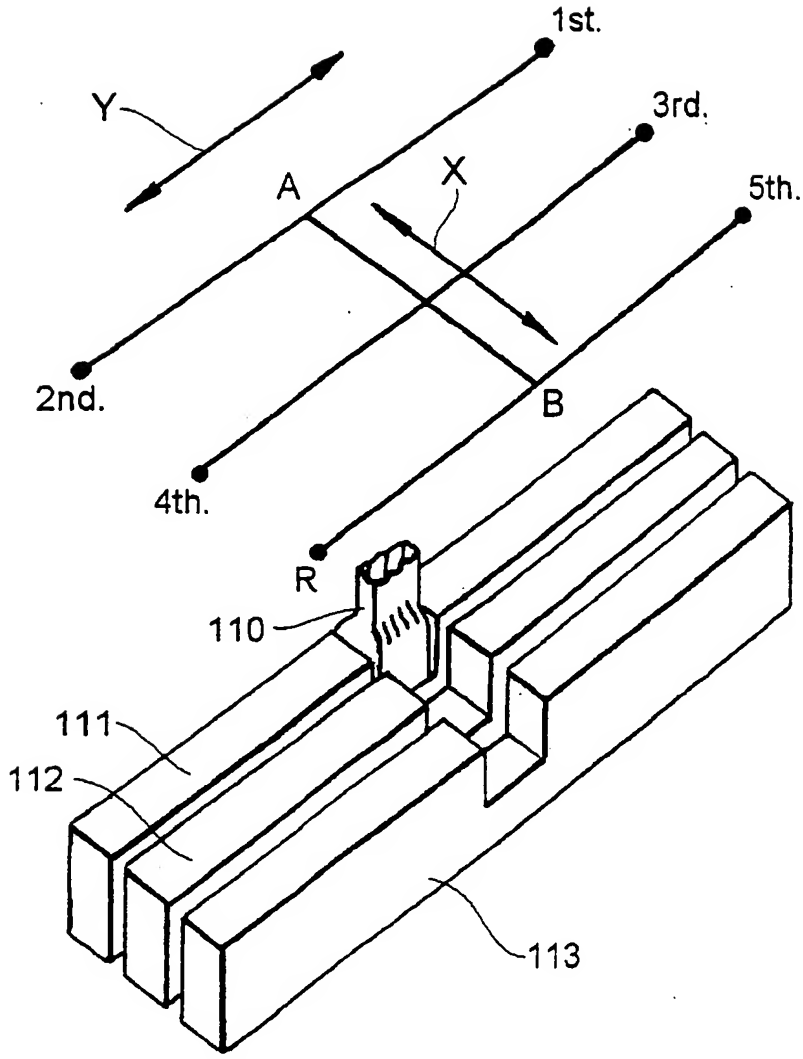


Fig 2.

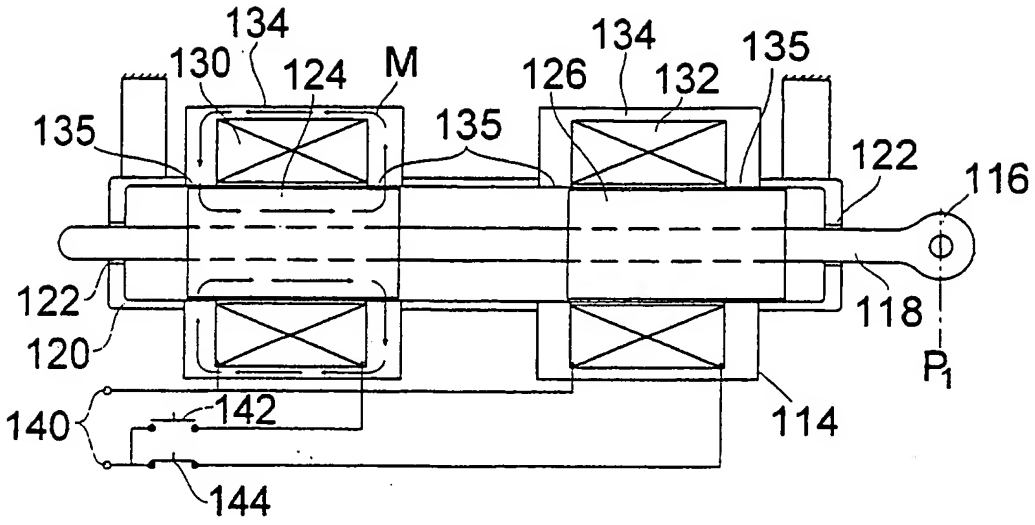

134
130
124
M
135
135
134
126
132
135
122
116
122
120
118
P1
140
142
114
144

Fig 3.

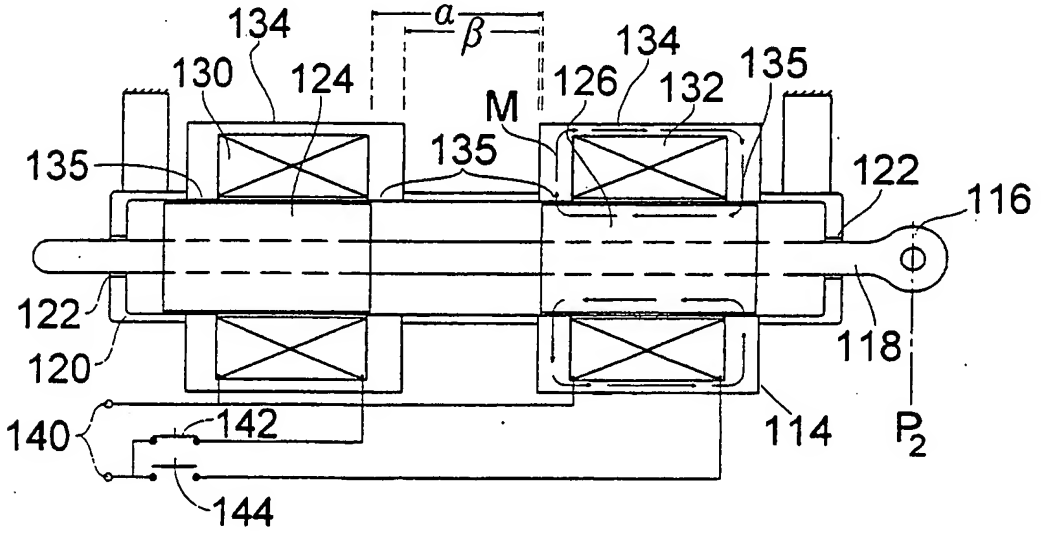
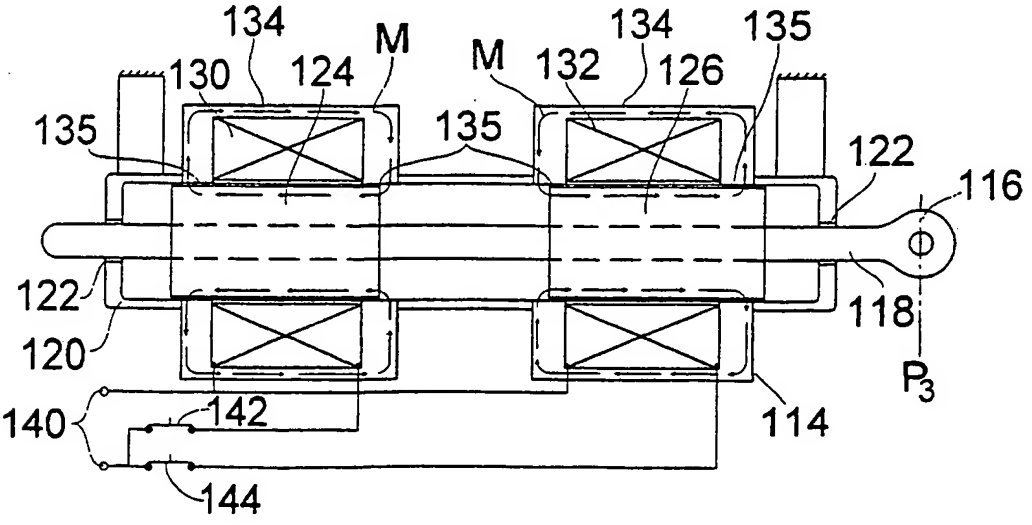

a
β
134
130
124
M
135
135
134
126
132
135
122
116
122
120
118
P2
140
142
114
144

Fig 4.


134
M
130
124
M
132
134
126
135
135
135
122
116
122
120
118
P3
140
142
114
144

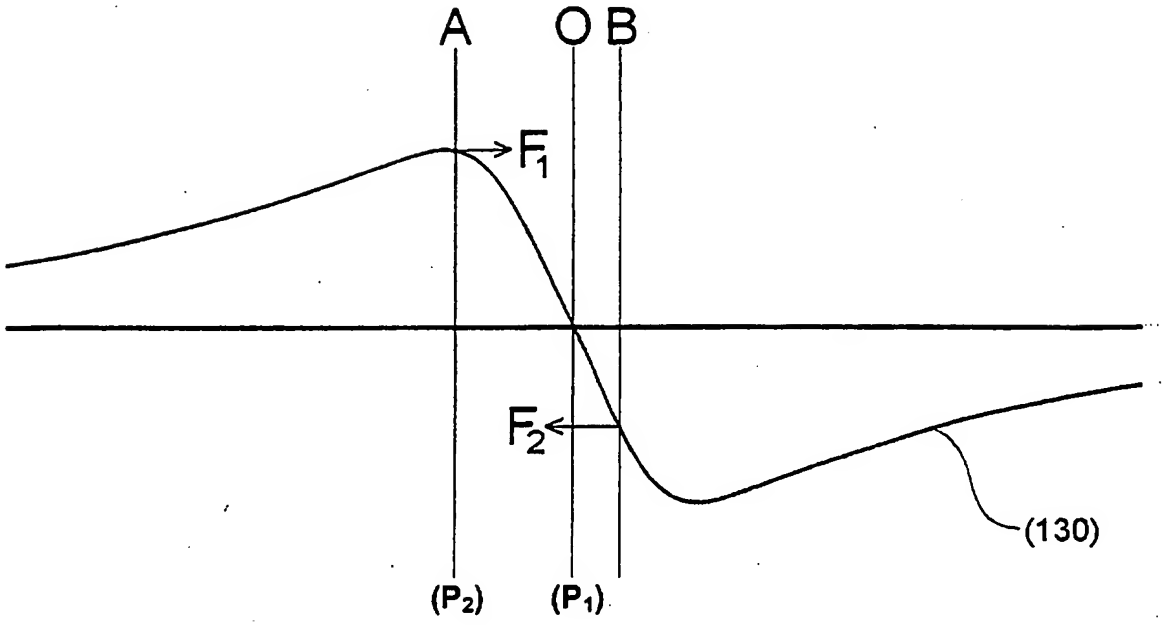


Fig 6.

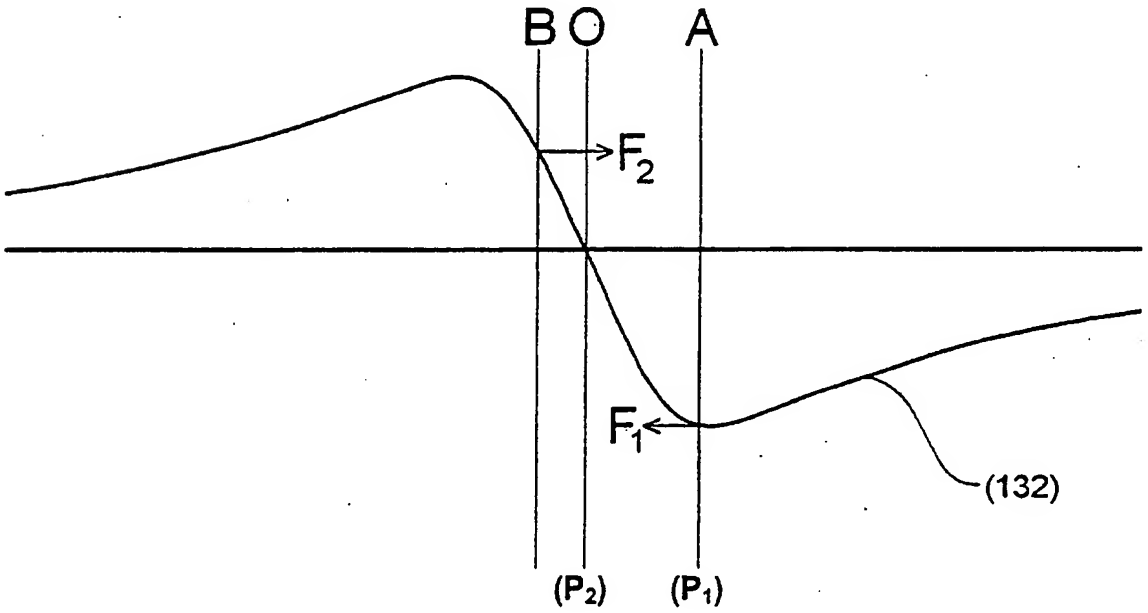


Fig 7.

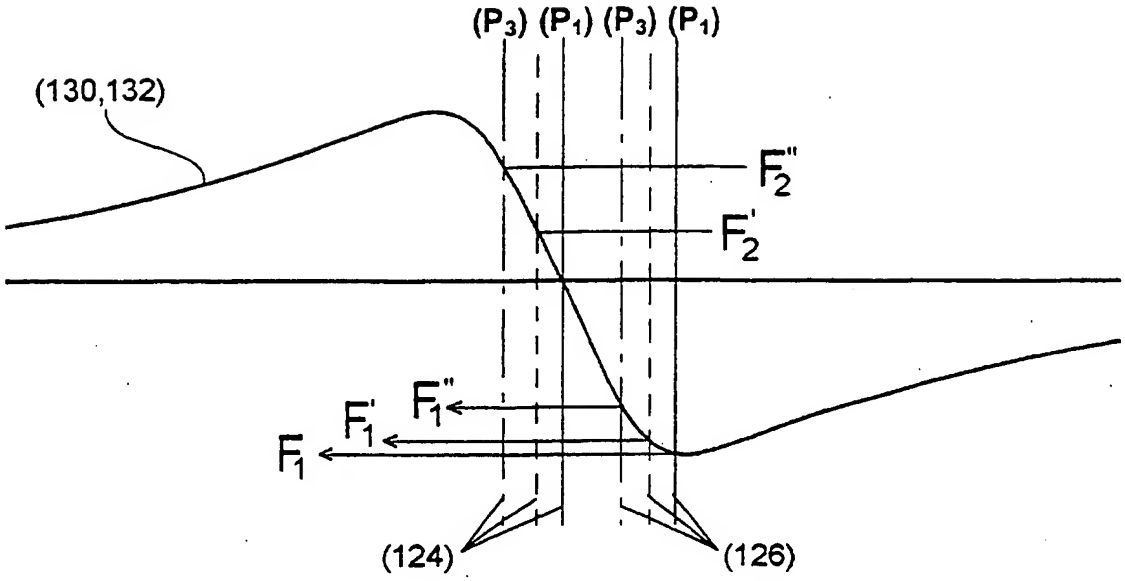

(P3) (P1) (P3) (P1)
(130,132)
F2"
F2'
F1"
F1'
F1
(124)
(126)

Fig 8

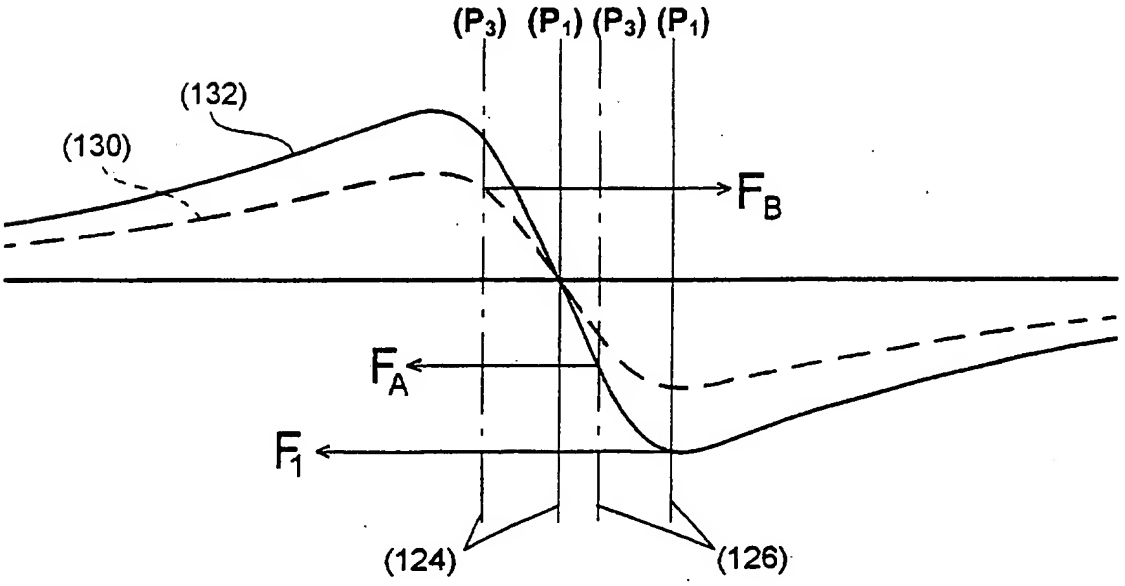

(P3) (P1) (P3) (P1)
(132)
(130)
FB
FA
F1
(124)
(126)

Fig 9.

GEARS

The present invention relates to a gear and a gear engagement mechanism and in particular a gear engagement mechanism for multi-ratio gearboxes used in automated transmission systems.

In automated transmission systems, hereinafter also automated gear systems, for example automated manual transmission systems, or automatic or semi-automatic transmission systems in particular including a multi-ratio gearbox of, for example, the type disclosed in WO97/05410 or WO97/40300, whose content is expressly incorporated in the disclosure content of the present application, a gear engagement mechanism comprises a plurality of shift rails or rods, each shift rail being associated with at least one or two gear ratios of the gearbox, via a selector fork and synchromesh unit, so that axial movement of each shift rail in either direction will engage one of the associated gear ratios.

A selector member is moved in a selected direction transverse to the shift rails, to be indexed with and engage a selected one of the shift rails and in a shift direction, axially of the shift rails, to move the selected shift rail axially in one direction or the other to engage a selected gear ratio.

In accordance with WO97/05410 and WO97/40300, the selector member is moved in the first and second directions by means of hydraulic actuators. DE19734023, whose content is expressly incorporated in the disclosure content of the present application, discloses the use of electric motors to move the selector member in the first and second directions respectively.

For a 5-speed gearbox the gear engagement mechanism will normally include three shift rails. The actuator for moving the selector member in a direction transverse to the shift rails must consequently be capable of indexing the selector member into one of for example three positions depending on the number of shift rails. Hitherto, this has been achieved by means of pneumatic or hydraulic actuators and appropriate control valves or by an electric motor.

In gear systems with two or four shift rails, two or four positions are

derived accordingly. The number of shift rails is not limited, and depends rather on the gear system being used. For heavy goods vehicles or other vehicles, gear systems with more than four shift rails may also be used.

The objective of the invention is to create an economical gear engaging mechanism which is compact in dimensions and rapid in actuation.

The present invention provides a gear engaging mechanism which utilises a solenoid actuator to move the selector member in the select direction, to one of for example three positions. An electromagnetic actuator can also be provided for moving the select actuator in the shift direction, parallel to the alignment of the shift rails.

In accordance with one aspect of the present invention, a gear engagement mechanism comprises for example three shift rails arranged parallel to one another, each shift rail being associated with at least one or two other gear ratios of a gearbox whereby axial movement of each shift rail will cause engagement of a gear ratio associated therewith, a selector member arranged to be moved in a first direction transverse to the axis of the shift rails to be indexed with and engage a selected one of the shift rails and a selector actuator adapted to move the selector member transversely of the shift rails to one of for example three positions, each position corresponding to a different one of the shift rails, said selector actuator comprising an armature mounted for axial movement transverse to the axis of the shift rails, said armature comprising a rod made of non-magnetic material, said rod having a pair of iron cores mounted in axially spaced apart relationship thereon; a pair of annular electromagnetic coils positioned in axially spaced apart relationship coaxially with the armature, each coil having pole pieces, the pole pieces within limits of movement of the armature between a first and a second position, axially overlapping a different one of the cores, the spacing of the coils being different to that of the cores, and means being provided for selectively connecting each coil to an electrical power source.

With the solenoid actuator described above, connection of either coil to the electric power source will generate a magnetic field which will cause the core overlapped by the coil to move so that it becomes centralised axially with the coil when the armature will be in the first or second

position. Consequently, by energising one coil or the other, the armature may be moved between the first and second positions. By connecting both coils simultaneously to the power source, both coils will act on their associated cores, moving the armature to a third position intermediate of the first and second position in which the forces acting on the cores are balanced.

Within the limits of movement of the armature between the first and second positions, the forces generated by the magnetic fields acting on the cores increase, the more the core is off-centred from the coil, the solenoid will consequently be self-centring on a selected position and there will consequently be no need for position sensors to indicate that the appropriate position has been reached. Changes in the inductance of the electrical circuit may however be used to confirm a change in the position of the solenoid actuator.

According to a preferred embodiment of the invention each coil will be energised to apply a force of the order of 20N on the associated core at maximum displacement, the force reducing to zero when the core is centralised. Preferably the coil will apply a force of about 10N to the associated core, as it approaches its centralised position.

An embodiment of the invention is now described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 illustrates diagrammatically an automated transmission system utilising a gear engagement mechanism in accordance with the present invention;

Figure 2 shows a gear ratio selector gate and associated shift rails used in the gear engagement mechanism of the transmission illustrated in Figure 1;

Figure 3 illustrates in side elevation the select actuator of the gear engagement mechanism used in the transmission illustrated in Figure 1 in a first position;

Figure 4 shows a view similar to Fig. 3 of the select actuator in a second position;

Figure 5 shows a view similar to Fig. 3 of the select actuator in a third position;

Figure 6 shows a force diagram for the select actuator for movement from the position illustrated in Fig. 4 to the position illustrated in Fig. 3;

Figure 7 shows a force diagram for the select actuator for movement from the position illustrated in Fig. 3 to the position illustrated in Fig. 4;

Figure 8 shows a force diagram for the select actuator for movement from the position illustrated in Fig. 3 to the position illustrated in Fig. 5; and

Figure 9 shows a force diagram similar to Fig. 8 for an alternative embodiment of the shift select actuator.

Figure 1 of the accompanying drawings shows an engine 10 with a starter and associated starter circuit 10a which is coupled through a clutch 14, such as a main drive friction clutch, with a multi-speed gear system 12, such as a synchromesh gear, via a gearbox input shaft 15. Fuel is supplied to the engine by a throttle 16 which includes a throttle valve 18, operated by accelerator pedal 19. The invention is equally applicable to electronic or mechanical fuel injection petrol or diesel engine.

The clutch 14 is actuated by a release fork 20 which is operated by a hydraulic slave cylinder 22, under the control of a clutch actuator control means 38.

A gear selector lever 24 operates in a gate 50 having two limbs 51 and 52 joined by a cross track 53 extending between the end of limb 52 and intermediate of the ends of limb 51. The gate 50 defines five positions; "R" at the end of limb 52; "N" intermediate of the ends of the cross track 53; "S" at the junction of limb 51 with the cross track 53; and "+" and "-" at the extremities of limb 51. In limb 51 the lever 24 is biased to the central "S" position. The "N" position of the selector lever 24

may be used. A gear indicator 60 is also provided to indicate the gear ratio selected.

As illustrated in Figure 2, the gear engagement mechanism 25 comprises for example three shift rails 111,112,113 mounted parallel to one another for movement in an axial direction. Each shift rail 111,112,113 is associated with one or two of the gear ratios of the gearbox 12, via a selector fork and synchromesh unit in conventional manner, so that movement of the shift rails 111,112,113 in one axial direction will cause engagement of one of the associated gear ratios and axial movement of the shift rail 111,112,113 in the opposite axial direction will cause engagement of the other associated gear ratio.

Typically; first and second gear ratios are associated with shift rail 111, so that axial movement of the shift rail 111 in a first direction will engage first gear or axial movement of shift rail 111 in a second direction will engage second gear; third and fourth gear ratios are associated with shift rail 112, so that axial movement of shift rail 112 in the first direction will engage third gear or axial movement of shift 112 in a second direction will engage fourth gear; and fifth and reverse gear ratios are associated with shift rail 113, so that axial movement of shift rail 113 in the first direction will engage fifth gear while axial movement of shift rail 113 in the second direction will engage reverse gear. With six-speed gear systems, as a rule four shift rails are used, in which situation the allocation is similar to that described above.

A selector member 110 is mounted for movement in a first direction X transverse to the axes of the shift rails 111,112, 113 and in a second direction Y, for movement axially of the shift rails 111,112 and 113. The selector member 110 may thus be moved in direction X along a neutral plane A-B, so that it may be indexed with and engage a selected one of the shift rails 111,112 and 113. The selector member 110 may then be moved in direction Y to move the engaged shift rail 111,112,113 axially in either direction to engage one of the gear ratios associated therewith.

The selector member 110 is movable in the first direction X by means of a solenoid actuator 114 as illustrated in Figs. 3 to 5. The selector member 110 can also be arranged in the second direction Y by means of an

corresponds to neutral; "R" corresponds to selection of reverse gear; "S" corresponds to selection of a forward drive mode; momentary movement of the lever to the "+" position provides a command to cause the gearbox to shift up one gear ratio; and momentary movement of the gear lever 24 to the "-" position provides a command to cause the gearbox to shift down one gear ratio.

The positions of the lever 24 are sensed by a series of sensors, for example micro switches or optical sensors, positioned around the gate 50. Signals from the sensors are fed to an electronic control unit 36. An output from the control unit 36 controls a gear engaging mechanism 25, which engages the gear ratios of the gearbox 12, in accordance with movement of the selector lever 24 by the vehicle operator.

In addition to signals from the gear selector lever 24, the control unit 36 receives signals from:

sensor 19a indicative of the degree of depression of the accelerator pedal 19;

sensor 30 indicative of the degree of opening of the throttle control valve 18;

sensor 26 indicative of the engine speed;

sensor 42 indicative of the speed of the clutch driven plate;

sensor 34 indicative of the clutch slave cylinder position; and

sensor 32 indicative of the gear ratio selected.

The control unit 36 utilises the signals from these sensors to control actuation of the clutch 14 during take-up from rest and gear changes, for example as described in patent specifications EP0038113, EP0043660, EP0059035, EP0101220 and WO92/13208 whose content is expressly incorporated in the disclosure content of the present application.

In addition to the above mentioned sensors, control unit 36 also receives signals from a vehicle speed sensor 52, ignition switch 54 and brake switch 56 associated with the main braking system, for example the footbrake 58 of the vehicle.

A buzzer 50 is connected to the control unit 36 to warn/indicate to the vehicle operator as certain operating conditions occur. In addition or in place of the buzzer 50 a flashing warning light or other indicating means

electromagnetic actuator.

The solenoid actuator 114 has an armature 116 comprising a rod 118 made of non-magnetic material, the rod 118 being mounted for axial movement in a housing 120, in bearings 122, the housing 120 and bearings 122 also being made of non-magnetic material. A pair of cylindrical iron cores 124,126 are mounted in axially spaced relationship on the rod 118, the cores 124,126 being spaced apart by a distance 'α'.

A pair of axially spaced coils 130,132 are mounted on the housing 120 coaxially of the armature 116. The coils 130,132 are surrounded by an iron sheath 134 to provide pole pieces 135, which extend into close axially overlapping radial proximity to the cores 124, 126. The spacing 'β' between the coils 130 and 132 is however smaller than the spacing 'α' between the cores 124 and 126, the difference between the spacing cores 124,126 and the coils 130,132 '$\alpha - \beta$' being equal to the difference between the transverse positions of the selector member 110 when the selector member 110 engages shift rail 111 and the selector member 110 engages shift rail 113.

The coils 130 and 132 are connected to an electrical power supply 140 via switch means 142 and 144 respectively.

The rod 118 of actuator 114 is connected to the selector member 110 in a manner which will cause the selector member 110 to move in direction X upon axial movement of the armature 116, while permitting movement of selector member 110 in direction Y to effect axial movement of the selected shift rail 111,112 or 113.

Figure 6 illustrates a typical plot of the force exerted by the magnetic field M generated by the coil 130 on the core 124 against displacement from a centered position. The vertical axis of the plot represents force and the horizontal axis displacement from the centered position O. Forces above the horizontal axis are forces to the right while forces below the axis are forces to the left.

As illustrated in Fig. 6, in the centered position O, the force acting on core 124 is zero. As the core 124 is displaced to the right or left, between the

positions P_1 (illustrated in Fig. 3) and P_2 (illustrated in Fig. 4), that is while the core 124 overlaps the pole pieces 135, the force exerted on the core 124 increases. As the core 124 moves outwards of overlap with the pole pieces 135, the force acting on the core 124 diminishes.

When coil 130 is energised with the armature 116 in position P_2 as illustrated in Fig. 4, core 124 will be at position A of Fig. 6. The magnetic field M of coil 130 will consequently apply a force F_1 to the core 124, moving the armature 116 to the right. As the armature 116 moves to the right the force F_1 will diminish until, when the armature 116 reaches position P_1 (illustrated in Fig. 3) and the core 124 is at the centered position O, the force acting on core 124 will be zero. If the core 124 overshoots the centered position O, to say position B, then a force F_2 to the left will be exerted on the core 124 moving the armature 116 back to position P_1. The armature 116 will consequently be self centering on position P_1 when coil 130 is energised.

Movement of the armature 116 in this manner will move the selector member 110 connected thereto so that the selector member 110 is moved in the direction X along the neutral plane A-B of the gate illustrated in Fig. 2 to the position illustrated in Fig. 3 where selector member 110 will engage shift rail 111.

In similar manner, as illustrated in Fig. 7, if the armature 116 is in the position P_1, as illustrated in Fig. 3, energisation of coil 132 will move the armature 116 to position P2, as illustrated in Fig. 4, moving the selector member 110 into engagement with shift rail 113.

As illustrated in Fig. 8, if both coils 130 and 132 are energised while the armature 116 is in position P_1 (illustrated in Fig. 3), the force exerted by the magnetic field M generated by coil 130 on core 124 will be zero, the core 124 being centered with respect to coil 130. The magnetic field M generated by coil 132 will exert a force F_1 on core 126, causing the armature 116 to move to the left. As the armature 116 mov s to the left, the force to the left exerted on core 126 will diminish to F_1' while the magnetic field M generated by coil 130 will exert an increasing force F_2' to the right on core 124. The armature 116 continues to move until it

reaches position P_3 (as illustrated in Fig. 5) in which the forces F_1'', F_2'' exerted on core 124 and 126 in opposite directions are balanced.

In similar manner, the armature 116 may be moved from position P_2 to P_3 by energisation of both coils 130 and 132. The selector member 110 may thus be moved into engagement with shift rail 112.

By appropriate energisation of coils 130 and 132, the armature 116 and selector member 110 connected thereto may be moved in direction X to engage the selector member 110 with each of the shift rails 111, 112, 113 as required.

Preferably the coils 130, 132 and cores 124, 126 are designed so that on maximum displacement from the centered position O within the working limits, the magnetic fields M generated by coils 130, 132 will exert a force of the order of 20N on the core 124, 126 respectively. This force diminishes at an increasing rate so that as the core 124, 126 approaches closely to the centered position the force exerted is of the order of 10N, the force reducing to zero at the centered position.

In the above embodiment the magnetic fields generated by coils 130, 132 are equal and the cores 124, 126 are of identical construction. As a consequence, when both coils are energised, equal but opposite forces will be applied to the cores 124, 126 when the armature is located mid-way between positions P_1 and P_2. The shift rail 112 must consequently be evenly spaced between shift rails 111 and 113. Where this is not possible due, for example, to packaging restraints with regard to the gearbox, the intermediate position P_3 of the armature 116 may be adjusted by suitable design of the cores 124, 126 and/or coils 130,132, so that when both coils 130,132 are energised, the forces applied by the magnetic fields M on the cores 124 and 126 respectively, will be different and the balance point P_3 will move to the required position, as illustrated in Fig. 9.

As illustrated in Fig. 9, as the armature 116 moves from position P_1 to position P_3, because of the reduced force F_B applied by coil 132 on core 126, the balance point at which force F_A balances force F_B is displaced from the mid-point between positions P_1 and P_2 to the right. This may

be achieved by utilising cores of different dimensions or coils with different numbers of turns. Alternatively, different energising currents may be applied to the coils 130 and 132 to achieve the required balance position P_3.

The actuator 116 in accordance with the present invention may be used in a gear engagement mechanism of the type disclosed in GB 0001364.9, whose content is expressly incorporated in the disclosure content of the present application, whereby movement of the selector member by actuator 116 will be translated into axial movement of the engaged shift rail in order to engage the selected gear. Alternatively other means, for example electric motors or solenoids may be used to move the selector member in the Y direction.

The patent claims submitted with the application are proposed formulations without prejudice to the achievement of further patent protection. The applicant reserves the right to submit claims for further combinations of characteristics, previously only disclosed in the description and/or drawings.

Reference back used in sub-claims refer to the further development of the subject of the main claim by the characteristics of the respective sub-claim; they are not to be understood as a waiver with regard to achieving independent item protection for the combination of characteristics in the related sub-claims.

Since the subject of the sub-claims can form separate and independent inventions with reference to the prior art on the priority date, the applicant reserves the right to make them the subject of independent claims or of division declarations. Furthermore, they may also contain independent inventions which demonstrate a design which is independent of one of the objects of the preceding sub-claims.

The embodiments are not to be considered a restriction of the invention. Rather, a wide range of amendments and modifications is possibl within the scope of the current disclosure, especially those variations, elements and combinations and/or materials which, for example, the expert can learn by combining individual ones together with those in the general

description and embodiments in addition to characteristics and/or elements or process stages described in the claims and contained in the drawings with the aim of solving a task thus leading to a new object or new process stages or sequences of process stages via combinable characteristics, even where they concern manufacturing, testing and work processes.

CLAIMS

1. A gear engagement mechanism with at least two shift rails arranged parallel to one another, each shift rail being associated with at least one different gear ratio of a gearbox whereby axial movement of each shift rail will cause engagement of a gear ratio associated therewith, a selector member arranged to be moved in a first direction transverse to the axis of the shift rails to be indexed with and engage a selected one of the shift rails and a selector actuator adapted to move the selector member transversely of the shift rails to one of three positions, each position corresponding to a different one of the shift rails, said selector actuator comprising an armature mounted for axial movement transverse to the axis of the shift rails, said armature comprising a rod made of non-magnetic material, said rod having a pair of iron cores mounted in axially spaced apart relationship thereon; a pair of annular electromagnetic coils positioned in axially spaced apart relationship coaxially with the armature, each coil having pole pieces, the pole pieces, within limits of movement of the armature between a first position and a second position, axially overlapping a different one of the cores, the spacing of the coils being different to that of the cores, and means being provided for selectively connecting each coil to an electrical power source.

2. A gear engagement mechanism according to claim 1 in which the shift rails are evenly spaced, the coils applying equal forces to the cores, so that when both coils are energised the balance position of the armature will be mid-way between the positions of the armature when each of the cores is energised independently.

3. A gear engagement mechanism according to claim 1 in which the shift rails are unevenly spaced, the coils being arranged to apply different forces to the cores overlapped thereby so that when both coils are energised, the balance position of the armature will be offset from the mid-way position between the positions of the armatures when each coil is energised independently.

4. A gear engagement mechanism according to claim 3 in which the cores and/or coils are designed to apply different forces to the cores when both coils are energised.

5. A gear engagement mechanism according to claim 4 in which the cores are of different dimensions.

6. A gear engagement mechanism according to claim 4 in which the coils have different numbers of turns.

7. A gear engagement mechanism according to claim 3 in which different energising currents are used to energise the coils.

8. A gear engagement mechanism according to any one of claims 1 to 7 in which each coil when energised will apply a force of the order of 20N on the associated coil, when the associated coil is of its maximum operational offset from its position when centred with the coil.

9. A gear engagement mechanism according to claim 8 in which each coil when energised will apply a force of the order of 10N on the associated core, as the core approaches its centralised position.

10. A gear engagement mechanism substantially as described herein with reference to and as shown in Figs. 1 to 5b.

11. A solenoid actuator for a gear engagement mechanism as claimed in any one of claims 1 to 8.

Application No: GB 0105045.9 **Examiner:** Jason Clee
Claims searched: 1 to 11 **Date of search:** 18 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2D

Int Cl (Ed.7): F16H: 61/28, 61/32 & 61/34

Other: Online: WPI, EPODOC & JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	DE 19920064 A1 (Daimler Chrysler AG) especially see the abstract and figures	

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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E Patent document published on or after, but with priority date earlier than, the filing date of this application.